HEWLETT PACKARD

44468A

DATA ACQUISITION/CONTROL ROM PAC

NOTICE

The program material contained herein is supplied without representation or warranty of any kind. Hewlett-Packard Company therefore assumes no responsibility and shall have no liability, consequential or otherwise, of any kind arising from the use of this program material or any part thereof.

Manual Part No. 44468-90000

Microfiche Part No. 44468-90050

P.O. Box 301, Loveland, Colorado, 80537 U.S.A.

Printed: December 1982

HEWLETT-PACKARD LISTENS

To provide better support for you, the Data Acquisition group needs your help. Your timely inputs enable us to provide higher quality software and improve the existing data acquisition pac software for your computer. Your reply will be extremely helpful in this effort.

1. Pac name_____

2. How important was the availability of this pac in making your decision to buy a Hewlett-Packard calculator/computer?

   [ ] Would not buy without it. [ ] Important. [ ] Not important.

3. What is the major application area for which you purchased the pac?_____

4. Please rate the usefulness of the programs in this pac.

Front Panel:	[ ] Essential	[ ] Frequently Used	[ ] Infrequently Used	[ ] Never Used
Data Logger:	[ ] Essential	[ ] Frequently Used	[ ] Infrequently Used	[ ] Never Used
Subroutines:	[ ] Essential	[ ] Frequently Used	[ ] Infrequently Used	[ ] Never Used

   List subroutines that you use or plan to use from this pac.

   _____

5. Did you purchase a printer? [ ] Yes [ ] No
   Did you purchase a cassette drive [ ] Yes [ ] No

6. What programs would add to this pac?

   _____

7. What additional application pacs would you like to see developed for data acquisition?

   _____

THANK YOU FOR YOUR TIME AND COOPERATION.

Name _____ Position

Company _____

Address _____

City _____ State

Zip _____ Phone

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY CARD

FIRST CLASS / PERMIT NO. 37 / LOVELAND, COLORADO

POSTAGE WILL BE PAID BY ADDRESSEE

HEWLETT-PACKARD COMPANY
LOVELAND DIVISION, Dept 4162
P.O. Box 301
LOVELAND, COLORADO 80537
U.S.A.

INTRODUCTION

Welcome to the world of high performance, low cost data acquisition and control systems. The programs in this Pac have been written specifically for use with the -hp- 3421A Data Acquisition/Control Unit. They provide flexability and programming power previously belonging only to large scale, computer driven systems.

This manual provides a description of each program available in the Pac, a set of instructions for using the program, and one or more example problems, each of which includes a list of keystrokes required for its solution. We think you will find the power and simplicity a unique and important asset to solving your measurement and control needs.

Before plugging in your Data Acquisition/Control Module, turn your calculator off, and be certain you understand the section Inserting and Removing Application Modules. Before using a particular program, take a few minutes to read A Word About Program Usage. This short section will explain a number of common features that are used in operating the programs.

You should first familiarize yourself with the 3421A by reading at least the first two chapters of the 3421A Operating, Programming, and Configuration manual. Then, experiment with the programs in this Pac by selecting a program and running it once or twice while following the complete examples in this manual. Thereafter, the programs prompting or the mnemonics on the overlays should provide the necessary instructions, which variables to input, which keys are to be pressed, and which values will be output.

We hope that the Data Acquisition/Control Pac will assist you in the solution to your measurement needs. We would appreciate knowing your reactions to the programs in this Pac, and to this end we have provided a questionaire inside the front cover of this manual. Would you please take a few minutes to give us your comments on these programs. It is from your comments that we learn how to increase the usefulness of our programs.

CONTENTS

INSTALLATION

This segment of the manual is divided into two parts: 1) Inserting and Removing Application Modules and 2) Configuring the System. Part 1 addresses the matter of connecting the Application ROM Pacs to the 41C/CV handheld computer. Before you insert or remove any application module familiarize yourself with this material. The second part tells you how to interconnect the 41C/CV computer, the 3421A Data Acquisition/Control Unit, the optional 82162A Thermal Printer and/or the optional 82161A Digital Cassette Drive.

Configuration information for the 3421A can be found in the 3421A Operating, Programming, and Configuration Manual.

Inserting and Removing Application Modules

The table below indicates the additional modules required for using the Data Acquisition/Control Pac. These modules are not supplied with this Application Pac.

Calculator	41C	41CV
HP-IL Module	82160A	82160A
Memory*	82170A Quad Mem	—
Timer*	82182A	82182A

* Required for the Data Logger program.

Up to four Modules can be plugged into the ports on the 41C/CV. While plugged in, the names of all programs contained in the modules can be displayed by pressing [CATALOG] 2.

CAUTION

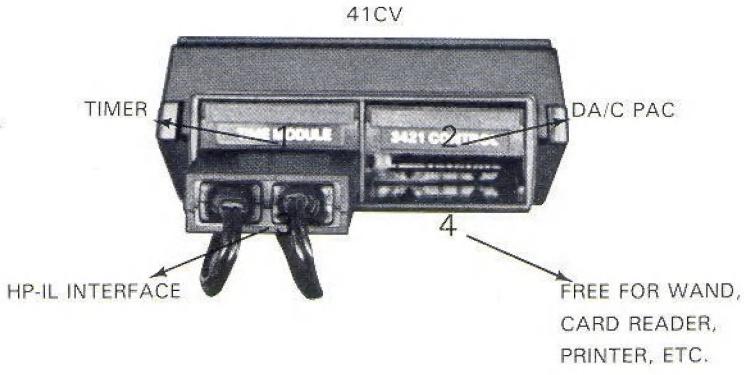
Always turn the HP-41C/CV off before inserting or removing any plug-in extension or accessory. Failure to turn the 41C/CV of could damage both the calculator and the accessory.

To Insert Application Modules

1. Turn the HP-41C calculator off! Failure to turn the calculator off could damage both the calculator and the module.

2. Remove the port covers. Remember to save the port covers; they should be inserted into the empty ports when no modules are inserted.

3. Insert the Application Modules with the label facing downward as shown. Never insert an Application Module into a lower numbered port than a Memory Module.



4. Be sure to place port covers over unused ports. Turn the calculator on and press CATALOG 2. Compare the catalog of programs to the list below.

Time Module

```
-TIME- C
ADATE
ALMCAT
ALMNOW
ATIME
ATIME24
CLK12
CLK24
CLKT
CLKTD
CLOCK
CORRECT
DATE
DATE+
DDAYS
DMY
DOW
MDY
RCLAF
RCLSW
RUNSW
SETAF
SETDATE
SETTIME
SETSW
STOPSW
SW
T+X
TIME
XYZALM
```

HP-IL Interface

```
-PRINTER 2E
ACA
ACCHR
ACCOL
ACSPEC
ACX
BLDSPEC
LIST
PRA
'PRAXIS
PRBUF
PRFLAGS
PRKEYS
PRP
'PRPLOT
'PRPLOTP
PRREG
PRREGX
PRS
PRSTK
PRX
REGPLOT
SKPCHR
SKPCOL
STKPLOT
FMT
--
```

```
-MASS ST 1H
CREATE
DIR
NEWM
PURGE
READA
READK
READP
READR
READRX
READS
READSUB
RENAME
SEC
SEEKR
UNSEC
VERIFY
WRTA
WRTK
WRTP
WRTPV
WRTR
WRTRX
WRTS
ZERO
--
```

```
-CTL FNS
AUTOID
FINDID
INA
IND
INSTAT
LISTEN
LOCAL
MANID
OUTA
PWRDN
PWRUP
REMOTE
SELECT
STOPID
TRIGGER
```

DA/C Module

```
-INST 1A-
DCV             FINDT           'TEMTX
ACV             FINDX           'TEMJX
TWO             FIND21          'TEMEX
FWO             CMD             'TENRX
TEM             CMDX            'TEMKX
REF             CMDXY           'TENSX
FRQ             DSP68           'TWRTDX
TOT             CLD68           'FWRTDX
DCVX            AK              'TWTH2X
ACVX            CLKY            'FWTH2X
TWOX            RDRGX           'TWTH5X
FWOX            CLAL            'FWTH5X
TEMX            --              'DECODE
FRQX                            'ALM
TOTX                            'LOG
C-F                             'DL
REFX                            'DLML
RTD                             'FP
TSC                             'FOR
TTC                             'REV
JSC                             ALENG
JTC                             ANUM
ESC                             AROT
ETC                             POSA
RSC                             ATOX
RTC                             XTOA
KSC                             SIZE?
KTC                             PSIZE
SSC                             RCLFLAG
STC                             STOFLAG
THM5                            X<>F
THM2                            REGMOVE
CLSX                            REGSWAP
OPNX                            GETKEY
OPH                             PCLPS
CLPX                            PASN
WRTXY                           CLKEYS
REDX
BITX
FIND50
FIND51
FIND52
FIND53
```


To Remove Application Modules

1. Turn the HP-41C off! Failure to do so could damage the both the calculator and the Module.

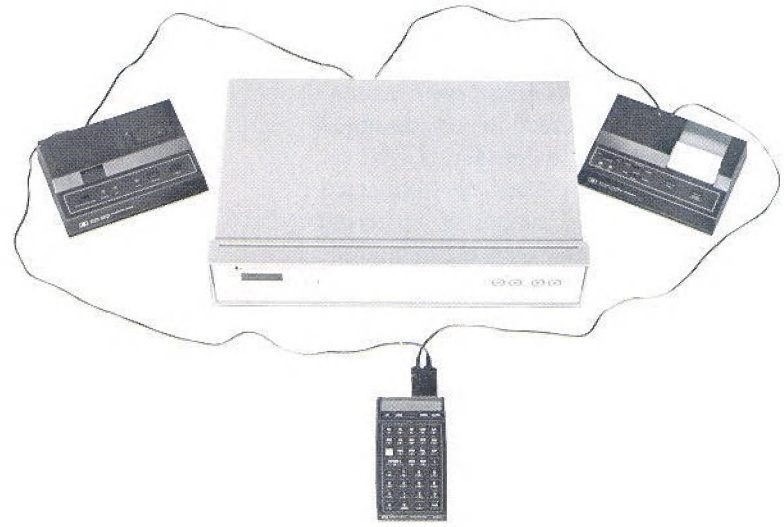
2. Grasp the desired Module handle and pull it out as shown.

3. Place a port cap into the empty port.

When using the HP-41C/CV calculator, port 4 will not be used. Optional accessories, such as the HP-82104A Card Reader or the HP-82153A Wand, may be plugged into this port. Remember, the 41C/CV must be turned off prior to inserting or removing those accessories.

Configuring the System

The 41C/CV and all peripheral devices, such as the 3421A, communicate with each other via the Hewlett-Packard Interface Loop (HP-IL). All devices are connected together in series forming a "communications circuit." Instructions from the 41C/CV or data from any peripheral are transferred from one device to the next around the circuit.



Connecting the Interface Loop

When using the 44468A ROM, a typical interface loop should consist of the 41C/CV computer,the 3421A Data Acquisition/Control Unit, and either the 82162A Thermal printer or the 82161A Digital Cassette Drive or both. Other peripherals may also be included. These devices should be connected according to the following instructions.

CAUTION

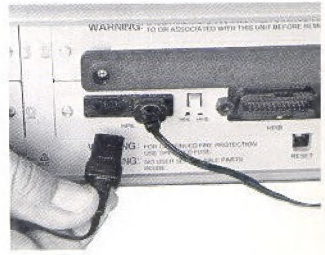
Be sure the 41C/CV is turned off before connecting or disconnecting the 82160A interface module and cable connectors. If this is not done, the computer may be damaged or the systems operation may be disrupted.

Install the 82160A Interface Module

For use with the 44468A ROM, it is recommended that the 82160A Interface Module be plugged into port number 3 on the computer. Push the module until it snaps into place. The module's switch should face down.

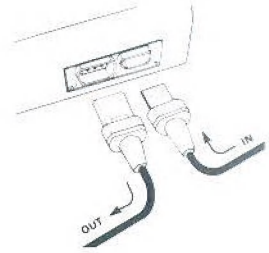
Connecting Peripheral Devices

The peripheral devices in the interface loop may be connected in any sequence - but all of the interface cables must form a continuous loop. All connections are designed to ensure proper orientation. Note: Although the 3421A may be connected anywhere in the loop, delays in triggering will be reduced if the 3421A is the first device in the loop.



To connect any peripheral device, first turn off the 41C/CV computer. Then merely disconnect the loop in any place and connect the new device into the loop at that place. All devices must be turned on for the interface to work properly.

The connectors indicate the direction of information transfer and the addressing of peripheral devices.



NOTE

If the plug-in HP 82143A Printer is to be used instead of the 82162A Printer, the print function switch on the interface module must be set to DISABLE.

Turn on all peripheral devices before turning on the 41C/CV. This will ensure proper auto addressing. To remove any device from the loop, first turn off the 41C/CV. Then unplug the device and reconnect the loop where the device was removed.

A WORD ABOUT PROGRAM USAGE

Catalog

When the Data Acquisition/Control Pac module is plugged into a port of the HP-41C, the contents of the module can be reviewed by pressing [CATALOG] 2 (the extensions catalog). Executing the CATALOG function lists by name each global label in the module as well as functions of any other extensions which might be plugged in. Remember that the CATALOG function lists the extensions in port 1 first, followed by ports 2, 3, and 4. The previous section listed the programs found in the Pac.

ALPHA and USER Mode Notation

The remainder of this manual uses a special notation to signify ALPHA mode. Whenever a statement is printed in gold, the [ALPHA] key must be pressed before the statement is keyed in. After the statement is input, press [ALPHA] again to return the calculator to its normal operating mode, or to begin program execution. For example, [XEQ] MVDC means press the following keys:
[XEQ] [ALPHA] MVDC [ALPHA] .

In USER Mode, when referring to the top two rows of keys (remember that the keys have been redefined), this manual will use the new key name, that is, the name assigned to that key by the program.

Selecting the Programs

Two main programs are supplied with your 44468A Data Acquisition ROM. These are the Front Panel Routine and the Data Logger Routine. In addition, several subroutines are provided for writing custom programs using a 'building block' approach. You should become familiar with the 3421A by reading at least the first two chapters in the 3421A Operating, Programming, and Configuration Manual prior to reading this Data Acquisition/Control Pac Manual.

The Front Panel routine transforms the 41C/CV into a sophisticated remote front panel for the 3421A. This program assigns each of the keys on the top two rows plus the shifted keys on the top row to one of the Standard Functions of the 3421A. To select this program, type: [XEQ] [ALPHA] FP [ALPHA] . When using this routine, use the Front Panel key overlay.

The Data Logger routine combines the programming and computational power of the 41C/CV with the measurement capabilities of the 3421A to create a flexible Data Logger. With this program you have the options of printing, recording, starting at a selected time, and waiting a selected time between scans. To run this program, type: [XEQ] [ALPHA] DL [ALPHA] . Use the DL key overlay with this routine.

Data Logger Overlay

Front Panel Overlay

Setting Proper Memory Size

When using the Data Logger routine, sufficient storage registers (memory) must be allocated prior to starting the routine. This simple procedure involves a minimum of 38 registers plus one (1) register for each measurement sequence must be set aside for the DL routine. A measurement sequence is defined as one measurement function (i.e., DC Volts) with an associated channel list (i.e., first channel - last channel.)

For example, suppose you have the following measurements to make:

T-Type thermocouple measurements on channels 2, 3, and 4.
A DC Voltage measurement on channel 5.
Thermistor measurements (2-wire ohms) on channels 6 - 8.

This would constitute three channel/measurement type combinations or sequences. Therefore, a minimum of 41 (38 + 3) registers should be set aside. This can be done by:

[XEQ] [ALPHA] SIZE [ALPHA] 041

Optional Printer

The optional 82143A printer may be used in place of the 82162A Thermal printer. When plugged into the -hp- 41CV along with this Application Module, all results will be printed autmatically just as with the 82162A Printer.

You may want to keep a permanent record of the values input to a certain program. A convenient way to do this is to set the printer PRINT MODE switch to NORMAL before running the program. In this mode, all input values and the corresponding keystrokes will be listed on the printer, thus providing a record of the entire operation of the program.

Use of Labels

The user should be aware of possible problems when writing programs into calculator memory using Alpha labels identical to those in the Data Acquisiton Module. The Alpha labels used in this Module are listed in the Appendix.

Key Assignments

If you have previously customized your keyboard with the ASN function, those reassignments will be cleared and reassigned by either the FP (Front Panel) or the DL (Data Logger) routines in this Application Pac.

When the DL routine is asserted, pressing [■] [DL] will clear all key assignments.

Channel Definition

Since this ROM Pac is intended for use with the 3421A, any time the word 'channel' is used, it implies a single channel inside the 3421A. Refer to the 3421A Operating, Programming, and Configuration Manual for more information on 'channels'.

FRONT PANEL

The 44468A's ROM Front Panel (FP) routine provides push-button, single channel measurements and control functions for the -hp- Model 3421A. A keyboard overlay is provided for the 41C/CV keyboard. You can easily check temperature, voltage, resistance, or frequency on a channel; or read or write digital information to the Digital I/O assembly.

Procedure

To use the FP routine, just connect the 41C/CV to the 3421A via HP-IL, take the 41C/CV out of the USER mode, and execute the FP routine:

[XEQ] [ALPHA] FP [ALPHA]

The 41C/CV display will show:

```
INITIALIZE- -
```

followed by

```
**HP 3421A**
```

and then

```
- - - - - -
```

At this point, the 3421A will reset to its power-on state.

Place the FP overlay on top of the 41C/CV keyboard and you are ready to begin taking measurements. Note: You may need to execute SCI 5 to assure full resolution.

The FP routine will periodically pause momentarily. This is because the 41C/CV can only acknowledge key closures while it is paused. Consequently, when you press a function key; i.e., DCV, BIT, FOR, etc., while the FP routine is running, there is a very slight chance that the 41C/CV might not catch it. If this occurs, simply press the function key again and hold it down until the 41C/CV responds.

To measure the DC voltage on channel 5 of the 3421A, simply press:

[DCV]

The 41C/CV will respond with:

DCV

followed by

CHANNEL?

Since you want to measure the voltage on channel 5, respond with:

5 [R/S]

Channel 5 will close in the 3421A and its internal voltmeter will continuously make DC voltage readings of channel 5 and display them on the 41C/CV display.

Suppose now you want to measure the resistance (2-wire measurement) from channel 12. Press: [2WΩ]

The 41C/CV will respond with:

TWO (for Two Wire Ohms)

and

CHANNEL

Respond by entering the channel number: 12 [R/S]

Suppose though, that you want to measure a resistance connected to the front panel of the 3421A. To do this you will need to make sure that all channel relays are open. To do this, press the OPN key: [OPN]

OPN

CHANNEL? [R/S]

Then command a resistance measurement without a channel number:

[2WΩ]

TWO

CHANNEL? [R/S]

To measure temperature (using T-type thermocouples) on channel 2:

[REF TEM]

TEM

CHANNEL? 2 [R/S]

If we also have T-type thermocouples connected to channels 3 and 4, we can easily increment the channel by pressing the FORward key:

[REV FOR] Pressing this key opens channel 2 and closes channel 3. The measurement function stays the same.

[REV FOR] Opens channel 3 and closes channel 4.

[REV] The REVerse key decrements the channel by opening channel 4 and closing channel 3.

To read the value of bit 2 of the option 050 Digital I/O assembly in slot 1 (bit address 12), press: [BIT]

BIT

CHANNEL? 1 2 [R/S]

The 41C/CV will display the value (either a 1 for closed or a 0 for open) of bit 12.

FP KEYBOARD DEFINITIONS

[ACV DCV] DC Voltage (5 ½ digits, autorange)
(Shift) AC Voltage (4 ½ digits autorange)

[REF TEM] Temperature (°C) using T-type thermocouples
(Shift) Measures Reference junction temperature

[4WΩ 2WΩ] Resistance (2-Wire Configuration, 5 ½ digits, autorange)
(Shift) Resistance (4-wire Configuration 5 ½ digits, autorange)

[TOT FRQ] Frequency (1 second gate time, 5 ½ digits)
(Shift) Totalize (65,535 counts maximum)

[WRT RED] Read a digital byte (8 bits) from specified slot
(Shift) Write a byte (8 bits) to the specified slot.
The 8 bits are represents by a decimal number between 0 and 255 which is the sum of the values of the bits set.

[CLS] Close the specified channel (actuator, multiplexer, digital bit).

[OPN] Open the the specified channel (actuator, multiplexer, bit)

[BIT] Reads the value of the specified bit

[RST] Resets the 3421A

[FP] Restarts the FP routine

[REV FOR] Increments the closed channel
(Shift) decrements the closed channel

[R/S] Run/Stop continues the FP routine after pausing for a channel number.

All other 41C/CV key definitions remain the same as for the standard 41C/CV. To clear assigned keys, execute:

[XEQ] [ALPHA] CLKEYS [ALPHA]

or

[XEQ] [ALPHA] CLKY [ALPHA]

DATA LOGGER

One segment of the 44468A ROM is a Data Logger routine. This routine offers a powerful data acquisition system that is easy to use and can be tailored to fit your measurement needs. The Data Logger (DL) routine also uses the 82182A Time module so that you can specify when the logging process is to begin as well as measurement intervals. Some method of recording the measured data is required such as the 82161A Digital Cassette Drive and/or the 82161A Thermal Printer.

A prompting format rather than a menu format is used in the DL routine. This means that defining your measurement functions and channels is as simple as answering a few questions. The DL routine has an intelligence of its own. For example, the routine will, on its own, determine if a printer is available. And if it is, you will be asked (prompted) if you want the measured data to be printed. If a printer is not available, you will not be prompted.

A complete data acquisition example will be used to describe the set up procedure for the Data Logger routine. Each step in the procedure is accompanied by a complete description of that step. Following this section, a flowchart is shown that shows the progression through the Data Logger set up routine.

The first and most important step in data acquisition is to completely define the problem the Data Logger will be solving. This involves stating the problem and defining the solution. Be specific. Answer the following questions:

1. What type of measurements are to be made; i.e., DC voltage, temperature measurements using T-Type thermocouples, etc?

2. What channels will the measurements be made on; i.e., DC voltage measurements on channel 2, 5, 7, 8, and 9?

3. Is the measured data to be recorded on a cassette tape (using an -hp-82161A Digital Cassette Drive)?

4. Is the data to be printed as it is gathered or will it be printed later?

5. What is the time interval between measurement passes?

6. How many complete passes (iterations) are to be done?

7. What time (and date) are the measurements to commence?

With the problem and solution stated, and the seven questions answered, we are ready to begin. For our demonstration, we'll use a passive solar collection system. First, define the problem and solution.

Problem Definition

Our solar collection system consists of a thermal mass (a brick wall) which acts as a solar collector and radiator. The sun shines through a large window and heats the brick wall, which in turn radiates its stored heat at night.

Some of the things we will want to measure in this system are the outside and inside ambient temperatures, heat flow through the window, solar radiation, and heat flow through the brick wall collector/radiator.

Outside temperature measurements will be made with T-type thermocouples, and inside temperatures will be measured with type 44004 thermistors (2252Ω @ 25°C). Solar radiation will be measured with a silicon cell pyranometer that produces a DC voltage output directly proportional to radiation intensity. (For now we will only monitor the voltage as a qualitative measure of whether the sun is out or not. Later we will see how to turn this measured voltage into a radiation intensity measured in watts per square meter (W/m2)). Heat flow can be calculated after measuring the difference between the two surfaces of the wall or window. We can define the Data Logger measurement functions as shown in Table A.

Table A. Data Logger Measurements

Channel 2.	T-type thermocouple; outside ambient temperature (°C)
Channel 3.	T-type thermocouple; outside window surface temperature (°C)
Channel 4.	T-type thermocouple; inside window surface temperature
Channel 5.	Pyranometer (DC Voltage); solar radiation intensity
Channel 6.	Thermistor (type 44004); inside ambient temperature (°C)
Channel 7.	Thermistor (type 44004); exposed wall surface temperature (°C)
Channel 8.	Thermistor (type 44004); interior wall surface temperature (°C)

We can now set up the Data Logger to make these measurements. Our Data Logger will use both the 82161A Digital Cassette Drive for permanent data storage and the 82162A Thermal printer for a convenient hard copy printout.

Next, we need to allocate storage registers in the 41C/CV computer. The formula given earlier is to allocate a minimum of 38 registers plus one register for each sequence. Since there are three types of measurements (thermocouple, DC voltage, and thermistor) we have three sequences. Therefore, a minimum of 41 registers must be allocated. This is done by:

XEQ ALPHA SIZE ALPHA 041

Before going any farther, don't forget to initialize the tape cassette (see "Recording Data With the 82161A Digital Cassette Drive"). You will also need to set the current time and date for the system (see "82182A Time Module Basics"). As far as the printer, make sure it has an adequate supply of paper and it's mode switch set to the "MAN" (manual) mode.

And we're ready to begin.

Make sure that the 44468A ROM, the 82182A Time Module, and the 82160A HP-IL Module are plugged into the 41C/CV. (Turn off the 41C/CV before installing the ROM modules.) Connect the 3421A, 41C/CV, 82161A, and 82162A together via the HP-IL in a single continuous loop. Put the 82161A and 82162A in their STANDBY mode (the 41C/CV will power them up automatically) and turn on the 3421A and 41C/CV.

STEP #

1. To run the Data Logger routine, key in the following command:

   XEQ ALPHA DL ALPHA

   The Data Logger routine will begin by displaying:

   HP3421A

   DATA LOGGER

This title will also be printed on the 82162A Thermal Printer. Following this, the 41C/CV computer will present a series of questions. Your response to these questions will determine the Data Logger set up. Make certain that the DL keyboard is in place on the 41C/CV keyboard to answer these questions.

41C/CV PROMPT	DESCRIPTION AND RESPONSE
2. NEW? Y/N	This prompt asks you if this will be a new Data Logger set up or whether you want to edit an existing set up. In our example, it is a new set up. Therefore, respond with: Y R/S

If it is not a new set up and you only wish to edit an existing set up, respond with:

N [R/S]

Note. [R/S] is the Run/Stop key which resumes execution of the routine after pausing for an input. For information on editing a set up, see "Editing" later in this chapter.

3. FIRST CH?

With this prompt you will enter in the first channel of a sequence. In our example, channels 2, 3, and 4 are used for thermocouple measurements. Therefore, respond with:

2 [R/S]

4. LAST CH?

This prompt asks for the last channel of a sequence. In our example, channel 4 is the last channel for thermocouple measurements (channel 3 is automatically included.) Therefore, respond with:

4 [R/S]

Note. The First Channel/Last Channel prompt are used to specify a contiguous set of channels (a Channel List). This channel list will be printed on the printer.

5. FUNCTION?

The FUNCTION prompt asks you what type of measurement is to be made on the channel list just specified. In our example, T-type thermocouples are to be measured. Therefore, respond with:

[T]

The measurement function, in this case: TTC, will be printed on the printer.

We have now specified our first measurement sequence: T-type thermocouple measurements on channels 2 through 4 of the 3421A.

6. FIRST CH?

Ready to set up the next sequence, the 41C/CV prompts for the first channel of the sequence. In our example, channel 5 is specified for the pyranometer. Therefore, respond with:

5 [R/S]

7. LAST CH?

Since only one channel is to be used in this sequence (channel 5) simply respond by pressing:

[R/S]

This says that only one channel is to be measured.

The printer will print: 5-5

8. FUNCTION?

The pyranometers output is a DC Voltage. Therefore, respond with: [DCV]

The printer will print the measurement function: DCV.

9. FIRST CH?

The first channel of our last sequence is channel 6. Therefore, respond with:

6 [R/S]

10. LAST CH?

The last channel in this sequence is channel 8. Respond to this prompt with:

8 [R/S]

11. FUNCTION?

Since we will be measuring temperature on channels 6 through 8 with a 2252Ω thermistor, respond with:

[THM]

The printer has recorded this sequence as channels 6-8 and measurement function THERMISTOR.

12. FIRST CH?

There are no more sequences to specify in our set up. We are ready to move on to the remaining prompts. Respond with:

[R/S]

13. RECORD Y/N?

At this point the Data Logger routine asks if you want to record the gathered data on the 82161A Digital Cassette Drive. If you do, respond with:

Y [R/S]

If you do not want to record the data, respond with:

N [R/S]

14. PRINT Y/N?

Do you want the data printed as it is gathered? If you do, respond with:

Y [R/S]

If you don't want the data printed as it is gathered, respond with:

N [R/S]

NOTE. When the 41C/CV was turned on it searched for a printer. If no printer was found, this prompt will not appear. If you want to connect a printer after you have entered your sequence, do it before the RECORD Y/N prompt. Turn the 41C/CV power off before disconnecting the interface. When the 41C/CV is powered up after the printer is installed, the DL program will pick up where it was interrupted and continue with the prompts.

15. INTERVAL

The INTERVAL is the time interval between complete measurement scans or passes. In our example, a complete scan includes channels 2 through 8. If we wanted the Data Logger to take a complete measurement scan every 10 minutes, respond with:

00.10000 [R/S]

Note that this is in HH.MMSS format. If you do not enter a time, but press only the [R/S] key, the Data Logger will run as fast as possible beginning one scan as soon as the previous one is finished.

16. ITERATIONS?

How many times are the measurements to be taken? If the measurements are to be taken over an 8 hour time period, with 10 minute intervals, we need a total of 48 iterations [6 scans per hour (10 minute intervals) times 8 hours equals 48 iterations.] Respond with:

48 [R/S]

A maximum of 999 iterations are possible. If a number is not given and you press the [R/S] key, the Data Logger will default to 1 iteration.

17. START TIME?

The START TIME asks for the time of day you want the Data Logger to begin its first measurement scan. The time may be entered in 24 hour format: hh.mmss. For our example, if we want the Data Logger to start at 2:00 PM, respond with:

14.0000 [R/S]

To use 12 hour format, enter the time as a negative number:

−2.0000 [R/S]

If no time is given, data logging starts immediately and there is no START DATE prompt.

18. START DATE

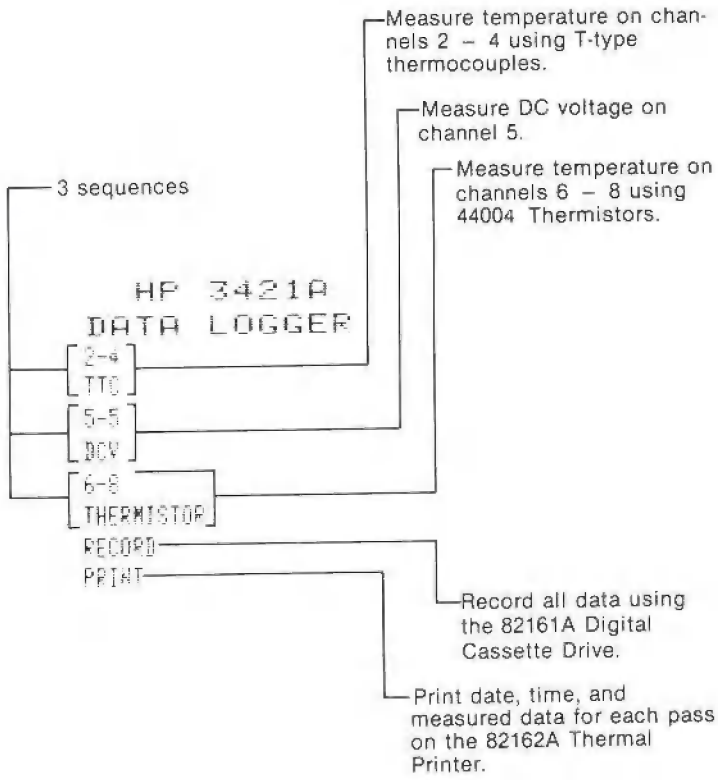
What day do you want the Data Logger to start? The date may be entered in either DD.MMYYYY or MM.DDYYYY format as appropriate. For example, if we want to start on October 23, 1982 respond with:

10.231982 [R/S]

Note. To determine what format you 41C/CV time Module is set for, execute: FS? 31. If the response is YES you are in DD.MMYYYY format. If the response is no, use the MM.DDYYY format. This should be done prior to running the Data Logger routine. Default is MM.DDYYYY

We have now completed the Data Logger set up defining our measurements. The entire Data Logger system now automatically "powers down" until the time and date that was specified. This is to conserve battery power. At the designated start time and date, the 41C/CV Time Module automatically "wakes up" the entire system and commences with the first measurement sequence.

The 82162A Thermal Printer gives us a record of our DL configuration or 'setup':

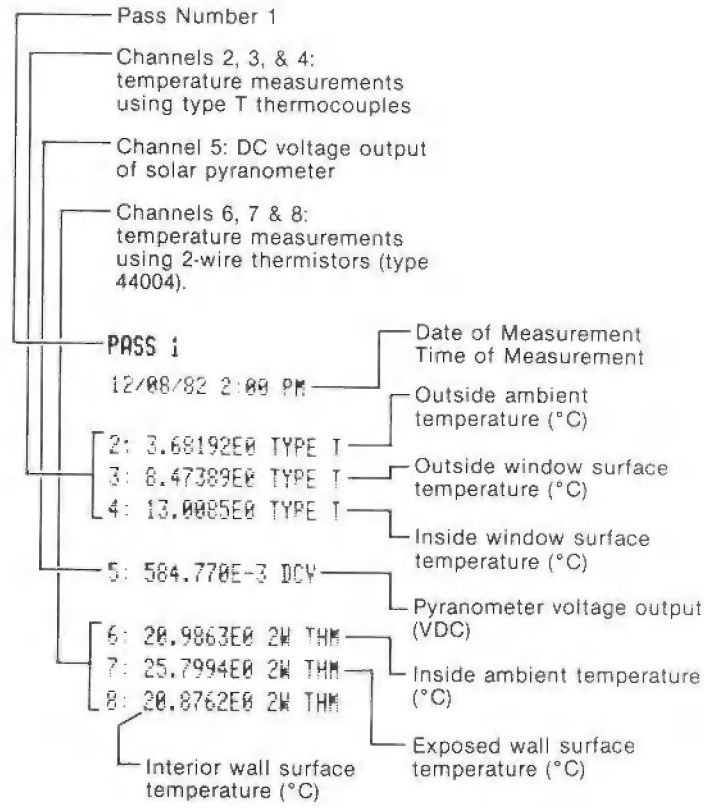


If desired, we could modify this DL setup. Inserting or deleting sequences is easily accomplished using the "EDITOR" included in the DL routine. See the section on "Editing an Existing Setup".

Measurement Results

When the start date and time are reached, the Data Logger system is automatically turned on from an alarm generated by the Time Module. The tape will rewind and be initialized (space for data files are marked

on the tape.) This process takes a minimum of 30 seconds (see section on System Timing). The printer will show the measurement scan or pass number ("PASS 1", "PASS 2", etc.), and the date and time that the pass started. Each measurement is printed with notations indicating the channel number and measurement function. The results of our first pass would be printed as:



All of this data would also be stored on tape and could be retrieved later (see "Recording Data with the 82161A Digital Cassette Drive") for analysis and processing.

At the end of the measurement pass, the Data Logger system will automatically "power down" to preserve battery life. The second pass would begin 10 minutes (the "INTERVAL" time) after the first pass began, in our example at 14:00 or 2:00p.m. A complete scan or measurement pass would occur every 10 minutes, producing a printout of the results as shown below. The results are also stored on tape.

```
PASS 2
12/08/82 2:10 PM

2: 4.82146E0 TYPE T
3: 9.69573E0 TYPE T
4: 13.7629E0 TYPE T

5: 649.336E-3 DCV

6: 21.8114E0 2W THM
7: 27.0216E0 2W THM
8: 21.6563E0 2W THM
 •
 •
 •
PASS 24
12/08/82 5:50 PM

2: -2.16447E0 TYPE T
3: 5.66249E0 TYPE T
4: 11.6378E0 TYPE T

5: 3.4548E-3 DCV

6: 20.0414E0 2W THM
7: 20.7763E0 2W THM
8: 23.3581E0 2W THM
```

Special Note

The 'INTERVAL', 'START TIME', and 'START DATE' prompts are used to supply input parameters for the Timer module alarm function 'XYZALM'. All valid inputs for the parameters in 'XYZALM' are also valid inputs to the three prompts. If an invalid input is entered for any of the three prompts, then an error message is displayed and the program loops back to the 'INTERVAL' prompt. This program utilizes a noninterupting control alarm. Refer to the 82182A Time Module Owner's Manual.

Editing An Existing Setup

Editing of an existing file is very easy once the initial set up has been entered. Editing allows you to obtain a listing of your current set up (by sequence) and insert or delete individual sequences. You will want to get a listing of the set up prior to inserting or deleting sequences as each sequence is referenced by a number.

Here is a list of the EDITOR commands and their uses:

COMMAND	DESCRIPTION
HELP	Prints and displays all available 'EDIT' commands.
LIST	Lists all entered sequences in the order they are executed. Editing reference numbers are listed to the far left. (see example)
DELETE	Deletes one specified sequence per execution. Sequence deleted is specified by the editing reference number.
INSERT	Inserts any number of sequences AFTER the sequence specified by reference number. To exit the INSERT mode, press [R/S] in response to the FIRST CH? prompt.
END	This ends the editing mode and continues with the RECORD Y/N? prompt.

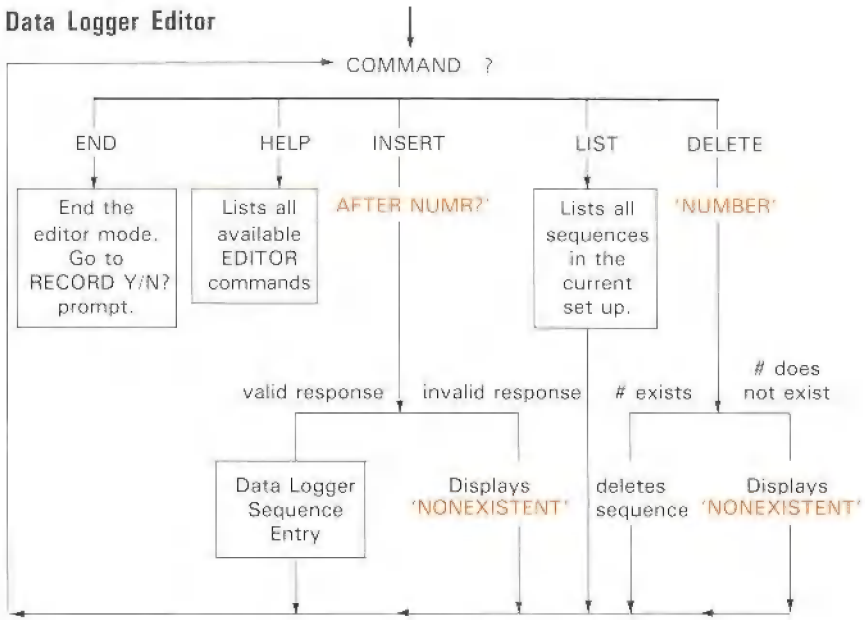
To enter the EDIT mode, simply run the Data Logger routine:

[XEQ] [ALPHA] DL [ALPHA] or from USER mode: [DL]

When the 41C/CV prompts with the NEW Y/N? respond with:

N [R/S]

The 41C/CV will then prompt with: EDIT Y/N?. To edit your existing set up, respond by pressing Y followed by the Run/Start key [R/S] . Wait for the COMMAND ? prompt. Enter the command name you wish to execute and press [R/S] . Follow the instruction prompts. The next section, entitled USER DEFINEABLE FUNCTIONS, shows several examples of using the DL EDITOR. The following flow chart shows the Editor sequence of operations.



User Definable Functions

Frequently there may be a need to express a parameter in units other than those the DL can measure directly. In our solar collection system, for example, a silicon cell pyranometer was used to measure radiation intensity. By some means, the DC voltage output of the pyranometer must be converted to units of radiation intensity (W/M^2). Such conversions can easily be done with User Definable Functions.

User Definable Functions (UDF's) are simply standard 41C/CV programs that become one of the functions available for use by the Data Logger. Because they are standard programs, they can be used to perform a wide variety of operations beside conversion routines. UDF's can be used to close 3421A actuator relays or communicate with the 44465A 8-bit Digital I/O Assembly.

We will show three examples of using the UDF's. The first example shows how to convert the DC voltage of our solar collector pyranometer to units of W/M^2. This exmple shows how to communicate directly with the 3421A. The second example will show demonstrate how to use one of the many subroutines resident in the 44468A ROM. Finally, the third example will show how to use measurement data from the preceeding sequence in a UDF.

Before You Begin

A total of 84 UDF's can be defined at any one time. These UDF'S must be assigned a label name of "USERx" where x is some number between 0 and 83, i.e., USER16. You may also find it helpful to remove the DL key overlay when writing the program. UDF's can be written at any time: either before starting the DL setup routine, or after you have completed it. You can even write them later and use the EDIT feature of the DL to include it in the setup.

Example 1. Solar Cell Pyranometer

Since you already have the Solar Collector setup in the 41C/CV, let's see how to edit the setup to include the new UDF. Perform the following steps.

ON USER	(This turns off the USER mode to prevent running the DL routine.)
■ GTO · ·	
PRGM	(puts the 41C/CV into the PROGRAM mode.)

Now we're ready to enter the conversion program. The equation used for our pyranometer is:

Radiation Intensity (W/M^2) = DC Voltage / 71.7μV

Since we will be measuring the DC voltage on channel 5 of the 3421A, lets call this program USER5. We could have called it anything from USER0 to USER83; the USER number has nothing to do with what channel(s) are being measured.

[f] [LBL] [ALPHA] USER5 [ALPHA]	The programs name, or Label, is USER5
[ALPHA] DCV5 [ALPHA]	DCV5 tells the 3421A to take a DC voltage measurement on channel 5.
[XEQ] [ALPHA] OUTA [ALPHA]	OUTA sends the command DCV5 to the 3421A.
[XEQ] [ALPHA] IND [ALPHA]	This inputs the measurement value into the 41C/CV's X-register.
[ENTER↑]	This moves the measured value into the Y-register.
71.1 [EEX] [CHS] 6 [÷]	The measured voltage is divided by 71.7 (μV) to obtain the radiation intensity units.
[f] [RTN] [f] [GTO] [.] [.] [PRGM]	The final result will be placed into 41C/CV's X-register before returning to the mainline DL routine. A 6 letter mnemonic can also be placed into the Alpha register. If no mnemonic is specified, the USER label name will be used.

A listing of "USER5" produced by the 82182A Thermal Printer:

```
01♦LBL "USER5"
02 "DCV5"
03 OUTA
04 IND
05 ENTER↑
06 71.7 E-6
07 /
08 RTN
09 END
```

Now we can edit the DL routine to add this UDF. To start the setup of the DL, put the 41C/CV back into the USER mode by pressing the [USER] and [DL] keys. Note that the DL key is on the keyboard overlay.

The DL routine will begin as usual and ask the setup questions that we saw earlier.

41C/CV DISPLAY	DESCRIPTION AND RESPONSE
HP3421A	
DATA LOGGER	
NEW Y/N?	Since we are going to edit the existing setup, respond with: N [R/S]
EDIT Y/N?	This prompt asks if we want to edit the setup. Since we do, respond with: Y [R/S]
– * – EDITOR – * –	This starts the Edit routine.
COMMAND?	The first thing we will need to do is get a listing of our current setup. Respond by typing: LIST [R/S]

```
HP 3421A
DATA LOGGER
-*-EDITOR-*-
LIST
0: 2-4, TYPE T
1: 5-5, DCV
2: 6-8, 2W THM
```

EDITOR sequence reference numbers

Since the pyranometer will now be measured in the USER5 routine, we can delete this measurement from the DL setup. When the 41C/CV prompts:

COMMAND?

We can delete the DCV measurement by responding with:

DELETE R/S

The 41C/CV will answer with:

DELETE

NUMBER?

Which asks for the reference number of the sequence to be deleted. We respond with:

1 R/S

DELETE 1

The sequence number 1 has now been deleted.

COMMAND?

Let's obtain a new listing of the Data Logger setup showing the deletion of the DC Voltage measurement on channel 5.

LIST R/S

```
LIST
0: 2-4, TYPE T
1: 5-5, USER5
2: 6-8, 2W THM
```

COMMAND?

Now we are ready to insert the USER5. We respond with:

INSERT R/S

The 41C/CV responds with:

INSERT

AFTER NUMR?

To place the USER5 routine between the thermocouple sequence and the thermistor sequence, insert USER5 after reference number 0 by responding with:

0 R/S

The 41C/CV responds with:

AFTER 0

FIRST CH?

Since the channel to be measured has already been specified, we don't need to specify one here. In the next example we will see a case where the channel is to be specified here. For now, simply respond with any number followed by R/S . The number that you choose will be printed out in front of the measurement even though it is not used by the subroutine.

R/S

LAST CH?

R/S

FUNCTION?

R/S

PRESS FN KEY

USER 0-83?

5 R/S will identify USER5 as the User Defined Function to be inserted.

USER5

FIRST CH?

To exit the sequence mode, press: R/S

COMMAND?

We are now finished with the edit mode. Let's get a new listing of the DL setup before exiting.

LIST R/S

```
LIST
0: 2-4, TYPE T
1: 5-5, USER5
2: 6-8, 2W THM
```

COMMAND?

Since we are finished with the Edit routine respond with:

END [R/S]

END

END EDITOR

Example 2

In this example we will look at two more features of the UDF's: using mnemonics and using one of the subroutines supplied with the 44468A ROM. For a complete list of all available subroutines, refer to the third section of this manual.

Suppose you desire to measure 3 frequency output type flowmeters with the 3421A. The relationship between frequency (Hz.) and and flow rate (gallons/minute) for each system in a 2'' I.D. pipe is:

Flow rate (gal/min) = Frequency (Hz.) × 16.76

Let's use the mnemonic 'GAL/MN' (mnemonics must be ≤ 6 characters). During the sequence setup phase, the following sequence will be selected.

First channel: 10
Last channel: 12
Sequence Label: USER16

To measure the frequency, let's use the 'FRQX' subroutine which is part of the 44468A ROM. When using these subroutines, the DL places the channel number which is to be measured into the X-register of the 41C/CV. The the appropriate user routine (in this example USER16) is executed. The user routine then performs its task, be it measurement or what ever, and passes the result to the X-register and a 6 letter mnemonic to the Alpha register before returning to the main DL routine. If no mnemonic is specified, the UDF name is used, i.e., USER16.

A listing of USER16 might look like this:

1	LBL 'USER16'	User function name
2	FRQX	When this ROM subroutine is executed, it will use the channel numbers specified by theDL. setup routine.
3	16.76	Scale factor
4	*	
5	'GAL/MN'	This is the mnemonic for the result.
6	SF10	Flag 10 alerts the DL routine that the mnemonic is in the Alpha register
7	RTN	Return to the main DL routine
8	END	End of UDF.

Note that when the UDF returns to the main DL routine, the result is in the X-register and the mnemonic is in the Alpha register. Both of these will be listed in the printout.

The DL sequence procedure for this UDF would look like this:

FIRST CH?	In response to the FIRST CH? prompt, type: 10 [R/S] . This specifies channel 10 as the first channel in the sequence.
LAST CH?	The last channel to be measured is channel 12. Therefore, respond with: 12 [R/S] .
FUNCTION?	[R/S]
PRESS FN KEY	[R/S]
USER 0-83?	16
USER 16	
FIRST CH?	[R/S]

We have now entered the UDF USER16 into the DL routine. The following pass listing shows how these measurements might look.

Example 3. Accessing Measurements From the Previous Sequence

It is possible to use measurements gathered by the previous sequence in a user function. When data is gathered during a sequence, it is stored in registers 02 to 31 in the 41C/CV. The first reading taken in each sequence, regardless of what channel was measured, is stored in register 02. Subsequent readings in each sequence are stored in order measured in succeeding registers, up to register 31. This allows for a maximum of of 30 readings per sequence. The registers are not initialized after each sequence, and therefore are available as the DL routine enters the next sequence. Consequently UDF's can access this data and use the measurement values to make control decisions.

Suppose we are using 7 J-Type thermocouples to measure various temperatures inside a canning retort. If any thermocouple measures a temperature in excess of 200°C, an advisory alarm is to sound. The DL routine must wait for someone to reset the alarm before it continues monitoring. The alarm will use channel 0 (an actuator) of the 3421A. The thermocouples measured are on channels 3 - 9.

For this example, we will use two sequences: the first to measure the thermocouples and record the temperatures; the second will make the decision to sound the alarm based upon the measurements from the first sequence.

1st. Sequence

First Channel:	3
Last Channel:	9
Function:	J

2nd. Sequence

First Channel:	100	(Since we will not actually be measuring a channel, this is only a dummy number. See Example 1.)
Last Channel:	100	
Function:	USER	
USER Function:	USER7	

Before looking at the UDF we would write to perform the monitoring task, lets examine how the measurements are stored within the 41C/CV.

Execution of the first sequence (channels 3-9, J-Type thermocouples) arranges the data in the registers in the following manner:

R00: "J TYPE"	Mnemonic for this measurement.
R01: 3.0090107	Sequence information fff.lll01tt f = first, l = last, t = function token.
R02:	Temperature from channel 3
R03:	Temperature from channel 4
R04:	Temperature from channel 5
R05:	Temperature from channel 6
R06:	Temperature from channel 7
R07:	Temperature from channel 8
R08:	Temperature from channel 9

With this format in mind, it is now straightforward to write a program to monitor these readings and sound the alarm if necessary. The following program shows how this can be done.

01 LBL "USER7"	Label for this UDF.
02 2.008	Registers where the readings are stored. (fff.lll)
03 STO 01	Use register 01 as a scratch pad register.
04 LBL 01	
05 200	Upper limit of temperature (200 °C).
06 RCL IND 01	Get the temperature measurement from the channel specified by register 01.
07 X>Y?	Is the temperature over the limit?
08 GTO 02	If 'YES' then sound the alarm.
09 ISG 01	Increment pointer (R01) to get next channel.
10 GTO 01	Rerun check if there are more channels.
11 RTN	Return to main DL routine if there are no problems.
12 LBL 02	
13 0	Select channel 0 of the 3421A.

14 CLSX	Close Channel X. (CLSx is one of the subroutines of the 44468A ROM. See Section 3 of this manual.)
15 STOP	Stops program execution until inspector presses R/S indicating that it is ok to continue monitoring.
16 GTO 01	Go back to get another channel.
17 .END.	End of UDF subroutine.

Recording Data With the 82162A Digital Cassette Drive

The 82162A provides the battery powered mass storage for your 44468A DL routines by interfacing to the 41C/CV via HP-IL. Each Mini Data Cassette (82176A) used with the 82161A can store up to 131 Kbytes of information. Detailed information on using the 82161A may be found in the 82161A Owners Manual and the 82160A HP-IL Module Owners Manual.

Getting Started

To use the 82161A with the 44468A DL routine, just connect the tape drive to your system with HP-IL cables and put the 82161A in its STANDBY mode. Before you begin logging data, erase and initialize the tape cartridge with the 41C/CV's NEWM command. To allow for the maximum allowable number of data files (447) execute the command:

XEQ ALPHA NEWM ALPHA 447

Once the tape is initialized, you are ready to begin logging data.

Data Organization and Capacity

Measurement results are stored on tape with one data file for each pass or measurement scan. Each file is given the name of its pass number. In other words, pass number 1 is stored in tape file "1", pass number 2 is stored under file name "2", etc. The file for each pass is composed of registers containing the date, time, and results of the pass. Each pass, or data file, is organized as shown in Table B.

Table B. Tape Cassette Data File Organization

Register	Contents
0	Date of measurement pass
1	Time that measurement pass began
2	Sequence 1 measurement function (DCV, USERO, etc.)
3	Sequence 1, First-Last channel pointer
4	Sequence 1, first measured value
5	Sequence 1, second measured value
6	Sequence 1, third measured value.
.	
.	
.	
n	Sequence 1, last measured value
n + 1	Sequence 2, measurement function
n + 2	Sequence 2, First-Last channel pointer
n + 3	Sequence 2, first measured value
.	
.	
.	
p	Sequence 2, last measured value
p + 1	Sequence 3, Measurement function
p + 2	Sequence 3, First-Last channel pointer
p + 3	Sequence 3, first measured value
.	
.	
.	
x	Last sequence, last measured value

The maximum number of passes that can be stored on one tape cassette depends on the number of registers used per pass, which in turn depends on both the number of channels measured and the number of sequences measured. Table C shows the maximum number of scans that can be stored on tape.

Table C. Maximum Passes Storable on Tape

Number of Registers per Pass	Maximum Number Passes Storable
4 (min. possible)	2039
10	1164
13	959
16	815
24	582
33	440
62 (max. possible)	247

Note: These values reflect tape storage capacity only. Battery power availabity may limit the total number of measurements to less than shown above. The DL routine limits total number of passes storable to 999.

Erasing Stored Data

To erase the entire tape, simply do another:

XEQ ALPHA NEWM ALPHA 447

To erase an individual file containing a single pass, place the pass number ("1", "2", "3", etc.) in the 41C/CV's ALPHA-register and:

XEQ ALPHA PURGE ALPHA

Printing the Data Tape Cassette Record

Once the measured data has been recorded on a cassette tape, how do you get it off the tape and printed on the thermal printer? The following program can be used to print the measurement results of a specified measurement pass.

PRGM

■ LBL ALPHA PRINT ALPHA

ALPHA 1 ALPHA

■ CLx/A

XEQ ALPHA SEEKR ALPHA

■ LBL 01

■ SF 25

XEQ ALPHA READRX ALPHA

XEQ ALPHA FC? ALPHA 25

XEQ ALPHA STOP ALPHA

XEQ ALPHA PRREGX ALPHA

■ GTO 01

■ GTO . .

```
01*LBL "PRINT"
02 "1"
03 CLX
04 XEQ "SEEKER"
05*LBL 01
06 SF 25
07 READRX
08 FC? 25
09 STOP
10 PRREGX
11 GTO 01
12 END
```

Program line #2 can be changed to reflect the "pass" number that you want printed out. For example, if you wanted the results of pass number 6, replace program line 2 with the number "6". By changing the number in program line 2, each of the data files can be printed on the thermal printer.

The data is printed in the following sequence:

Date (MM.DDYYYY)
Time (HH.MMSS)
Mnemonic (function) of first sequence (i.e., DCV, USER0, FRQ, etc.)
Channel List of first sequence (i.e., first/last channels in format: FF.00LL)
Reading from first channel
Reading from second channel
.
.
.
.
Reading from last channel
Mnemonic of next sequence
Channel List of next sequence
Readings
.
.
.
.

82182A Time Module Basics

The 82182A Time Module provides time-keeping and alarm functions for the 44468A Data Logger routines, causing the system to "power up" at the beginning of each measurement scan. The 82182A itself can act as a timer, alarm clock, calendar, and stop watch. Detailed information on the Time Module may be found in the 82182A's Owner's Manual.

Setting the Time and Date

For your measurements to occur at the correct time and date, set the time and date before running the DL routine. To set the time of day, place the time to be set in the 41C/CV's X-register with a format of HH.MMSS. Then, execute the command SETIME. To illustrate, lets say the current time is 8:59 a.m. We want to set the time at exactly 9:00 a.m. Perform the following steps:

9.0000 (9 hours, 00 minutes, 00 seconds)

XEQ ALPHA SETIME

Then, at exactly 9:00, press the ALPHA key again.

You can display the current time by executing ■ ON

The date may be represented in either MM.DDYYYY (default) or DD.MMYYYY format. You can select the format by executing either the MDY command (MM.DDYYY format) or DMY (DD.MMYYYY format). To set the date, place the present date into the 41C/CV's X-register and:

XEQ ALPHA SETDATE ALPHA

System Timing

The exact timing of measurements in a setup greatly depends on the nature of the setup itself. Whether the printer or tape cassette (or both) are used, the number and type of measurement sequences, User Functions, and the number of channels in each sequence all effect system timing. General 3421A timing and measurement speed information can be found in the 3421A Operating, Programming, and Configuration Manual.

Times for some of the events that occur for the passive solar collection demo are shown in Table A. This is an example of a system measuring 7 channels (3 thermocouples, 1 DC Voltage, and 3 thermistors), and recording and printing the data. This 7 channel scan was performed 48 times over an 8 hour period (every 10 minutes).

As the measurement scans or passes continue, data is stored farther down the tape, causing the the tape access time to increase. This causes the total "pass time" (the time from power-up to power-down of a single pass) to gradually become longer as the passes progress.

Note also that the first measurement is not made immediately after the system powers-up. What actually occurs is that the system powers-up; the cassette tape rewinds, marks the tape directory, forwards the tape for the next data file; and the printer prints the pass heading. All this is done before the first measurement is made. Note the time difference between Power-Up and Channel 2 measured in Table A.

Therefore, use discretion when selecting the time interval between scans. Too short of a time interval may cause measurements to begin later than expected. The time stored with the pass will indicate when the pass actually began. An error bell will sound in the 41C/CV when measurements start late.

Table D. System Timing for 44468A DL Solar System Demo

Event	Time (HH.MMSS)				
	Pass 1	Pass 2	Pass 4	Pass 12	Pass 24
Power-Up	14.0000	14.1000	14.3000	15.5000	17.5000
Print Pass #	14.0024	14.1025	14.3026	15.5029	17.5041
Channel 2	14.0037	14.1038	14.3039	15.5044	17.5056
Channel 3	14.0042	14.1044	14.3044	15.5049	17.5101
Channel 4	14.0046	14.1048	14.3049	15.5054	17.5105
Channel 5	14.0100	14.1102	14.3103	15.5108	17.5120
Channel 6	14.0114	14.1116	14.3117	15.5121	17.5134
Channel 7	14.0118	14.1120	14.3122	15.5125	17.5139
Channel 8	14.0122	14.1124	14.3126	15.5130	17.5143
Power-Down	14.0136	14.1137	14.3138	15.5142	17.5155

DL KEYBOARD DEFINITIONS

[E / T] T-Type thermocouple;
(Shift) E-Type thermocouple

[K / J] J-Type thermocouple;
(Shift) K-Type thermocouple

[R / S] S-Type thermocouple;
(Shift) R-Type thermocouple

[4WRTD / RTD] RTD (α = 0.00385), 2-Wire Measurement;
(Shift) RTD (α = 0.00385), 4-Wire Measurement

[4WTHM / THM] Thermistor (type 44004), 2-wire Measurement
(Shift) Thermistor (type 44004), 4-Wire Measurement

[DCV] DC Voltage (5 ½ digits, autoranging)

[ACV] AC Voltage (4 ½ digits, autoranging)

[2WΩ] Resistance (2-Wire configuration, 5 ½ digits, autoranging)

[4WΩ] Resistance (4-Wire configuration, 5 ½ digits, autoranging)

[FRQ] Frequency (1 sec. gate time, 5 ½ digits)

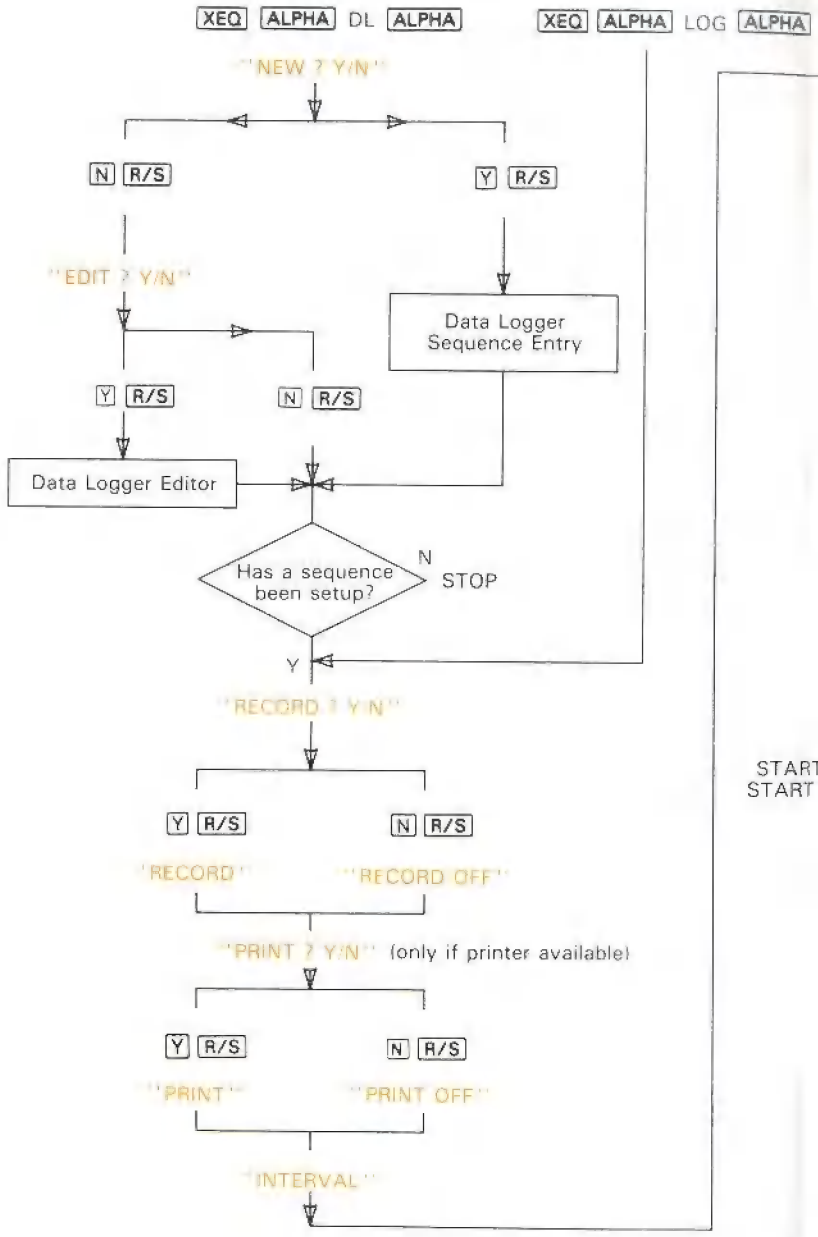
[DL] Starts the DL routine from the beginning
(Shift) clears all key assignments

[LOG] Moves DL routine to the Cassette/Printer setup point

[R/S] Run/Stop: Continues DL routine after it has stopped for a response to a question.

All other key definitions are the same as for the standard 41C/CV.

-hp- 44468A DATA LOGGER PROMPT/RESPONSE FLOW GRA



EFINITIONS

ple

ple

ple

ire Measurement;
5), 4-Wire Measurement

2-wire Measurement
4004), 4-Wire Measurement

autoranging)

autoranging)

uration, 5 ½ digits, autoranging)

uration, 5 ½ digits, autoranging)

me, 5 ½ digits)

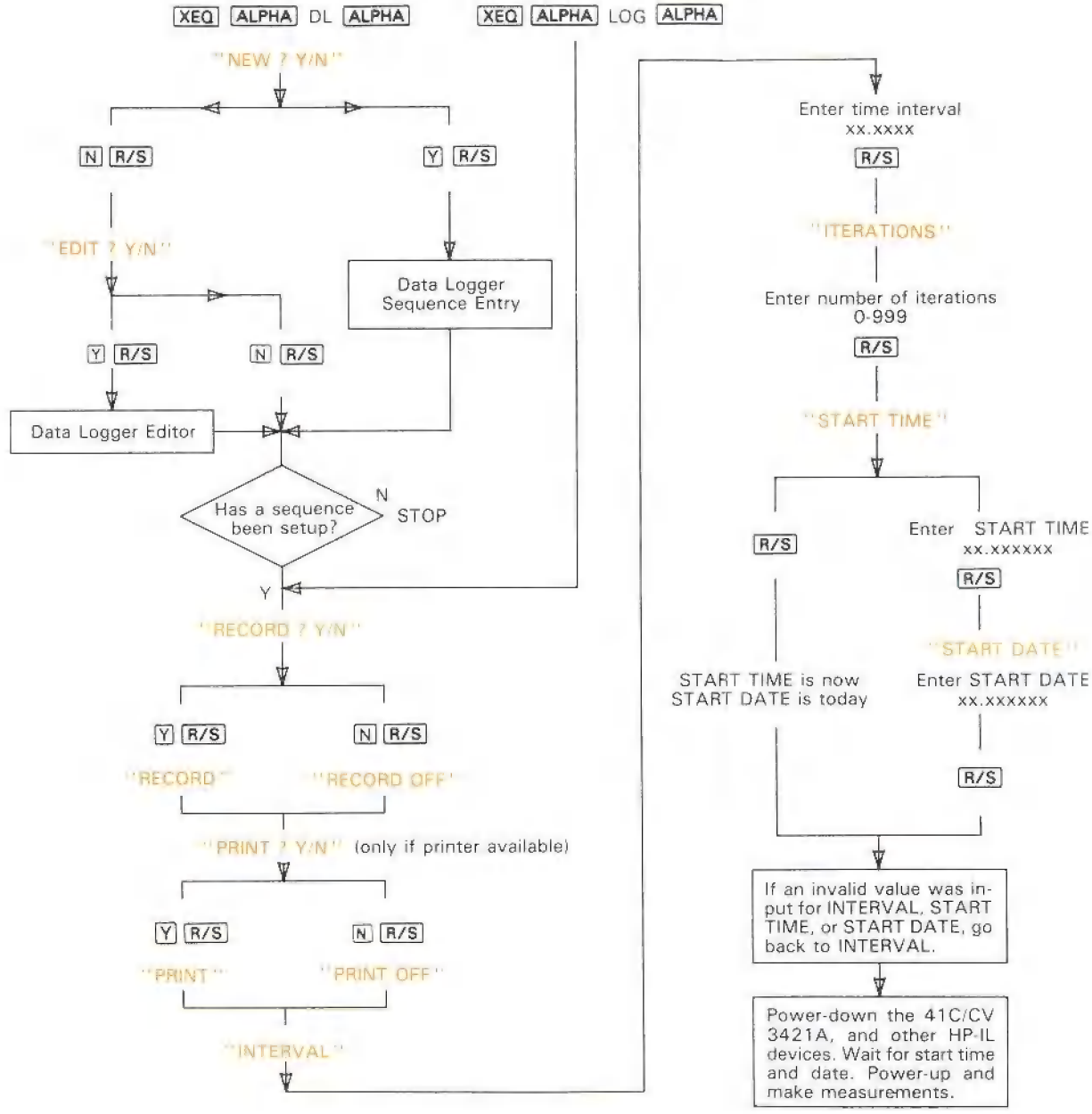
m the beginning
gnments

Cassette/Printer setup point

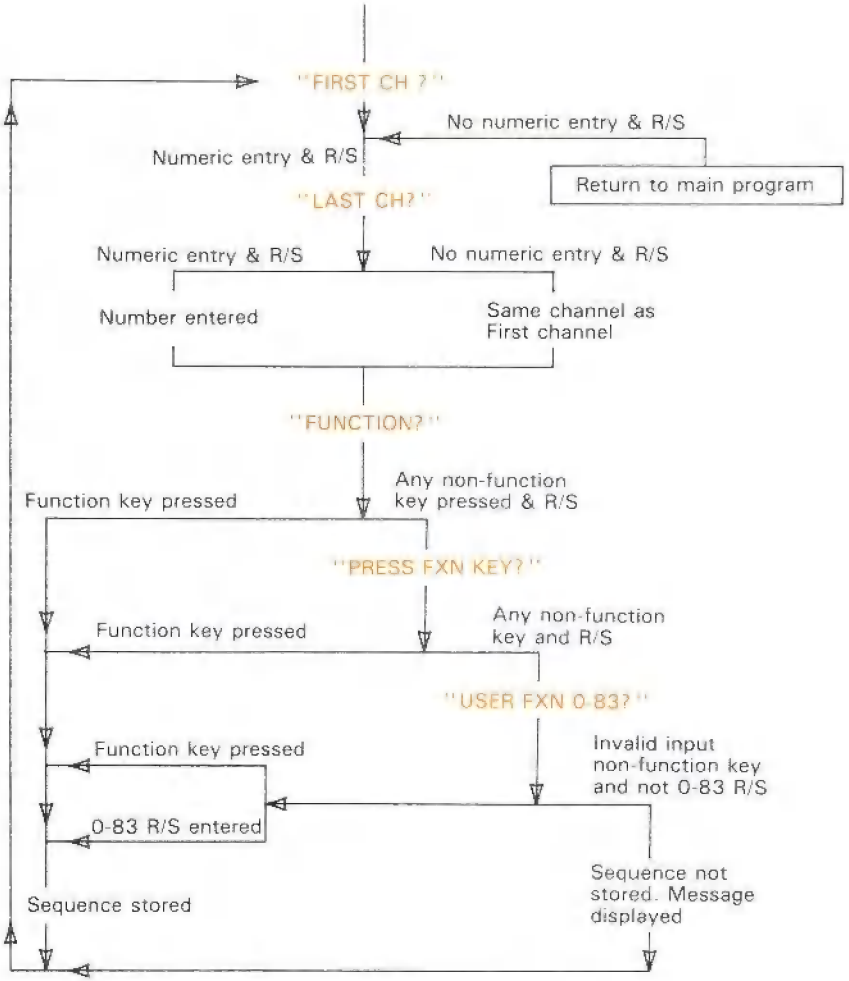
routine after it has stopped for

as for the standard 41C/CV.

-hp- 44468A DATA LOGGER PROMPT/RESPONSE FLOW GRAPH



DATA LOGGER SEQUENCE ENTRY



44468A SUBROUTINES

A total of 82 subroutines are available with the 44468A ROM. Of course, these 82 do not include the Front Panel or Data Logger routines. Many of the commands are simply duplications of the 3421A Standard Commands. This provides for easy programming using the 41C/CV. In other words, you don't need to go through the process of loading the command into the Alpha Register, executing OUTA and then executing IND:

[ALPHA] DCV [ALPHA]

[XEQ] [ALPHA] OUTA [ALPHA]

[XEQ] [ALPHA] IND [ALPHA]

With the 44468A ROM, you just execute the command:

[XEQ] [ALPHA] DCV [ALPHA]

The commands are broken down into 4 functional groups. Examples are provided for many of the commands.

All but two of these commands are for use with the -hp- Model 3421A. Those commands marked with an asterisk (*) may also be used with the -hp- Model 3468A/B Digital Multimeter. Two commands are for use with only the 3468A/B.

For more information concerning the way the commands are implemented in the 3421A, refer to the 3421A Operating, Programming, and Configuration Manual.

Standard Commands

The following commands are duplicates of the 3421A Standard Command set. These commands are of 2 forms: Standard and StandardX. Use the Standard commands when you want measurements from a channel that is already closed or, if no channels are closed, these commands can be used for measurements from the front panel terminals of the 3421A.

The StandardX Commands are identical to the Standard commands with the additional feature of being able to specify which 3421A channel the measurement is to be made from. To use these commands, the channel address (see 3421A Manual) that you want the measurement to be made from, must be placed in the 41C/CV's X-Register prior to executing the command.

In all functions where a channel is required, that channel number is required, that channel number is returned in LASTX after the function. Therefore, the reading is in the X-Register, and the channel is in LASTX.

Function	Measurement Units	XROM Number	Description
* DCV	Volts DC	21,01	This command takes one DC voltage measurement (5 ½ digit resolution, Autozero on, Autorange on). The measured value is returned to the 41C/CV's X-Register.
DCVX	Volts DC	21,09	This command takes one DC voltage measurement from the channel specified in the41C/CV's X-Register. All other multiplexer channels will be opened, then the channel specified in X will be closed, and the measurement made. The measurement result will be returned to the 41C/CV's X-Register.
* ACV	Volts AC	21,02	Same as DCV except one AC voltage measurement, 4 ½ digit resolution.
ACVX	Volts AC	21,10	Same as DCVX except one AC voltage measurement is made from the specified channel.
* TWO	Ohms	21,03	Same as DCV except a 2-Wire resistance measurement.
TWOX	Ohms	21,11	Same as DCVX except that one 2-Wire resistance measurement is made from the specified channel.
* FWO	Ohms	21,04	Same as DCV except a 4-wire resistance measurement.
FWOX	Ohms	21,12	Same as DCVX except that one 4-Wire resistance measurement will be made from the specified channel and its pair.

Function	Measurement Units	XROM Number	Description
TEM	°C	1,05	Same as DCV except a software compensated T-Type thermocouple temperature measurement.
TEMX	°C	21,13	Same as DCVX except that a software compensated T-type thermocouple temperature measurement will be made from the specified channel.
REF	°C	21,06	Measures the REFerence temperature on the 44462A Multiplexer Assembly.
REFX	°C	21,17	Measures the REFerence temperature on the 44462A Multiplexer assembly where the channel specified in the X-Register is located.
FRQ	Hz	21,07	Same as DCV except makes a frequency measurement using a 1 second gate time.
FRQX	Hz	21,14	Same as DCVX except that a frequency measurement is made on the specified channel.
TOT	counts	21,08	Totalizes events up to 65,535 Counts. The current answer is returned to the X-Register.
TOT	counts	21,15	Totalizes events on the specified channel.
CLSX		21,33	Close the 3421A channel whose number was placed in the 41C/CV's X-Register.
OPNX		21,34	Open the 3421A channel whose number was placed in the 41C/CV's X-Register.

Function	Measurement Units	XROM Number	Description
CLPX		21,36	Close the 3421A channel and its pair whose number was placed in the 41C/CV's X-Register.
WRTYX		21,37	Take the decimal value from the 41C/CV's Y-Register and write it to the 44464A Digital Assembly in slot whose number is in the 41C/CV's X-Register. (0<Y<255; X=1, 2, or 3)
REDX		21,38	Read the digital byte from the 3421A slot number located in the X-Register.
BITX		21,39	Read the bit whose address is located in the 41C/CV's X-Register.

Example 1:

To make a 2-wire Ohms measurement simply execute the TWO command:

[XEQ] [ALPHA] TWO [ALPHA]

Remember, either the channel to be measured must already be closed, or, if no channels are closed, the measurement can be made from the 3421A front panel terminals.

Example 2:

To make a DC voltage measurement on channel 21 (slot 2, channel 1) of the 3421A, execute the following:

2 1 [XEQ] [ALPHA] DCVX [ALPHA]

Temperature Commands

The following 27 commands perform various temperature measurement functions; everything from measuring RTD's, thermistors, and thermocouples, to simply converting from °C to °F. Like the Standard commands, the first set of Temperature commands assume that the channel you want to measure from is either already closed or the measurement is to be made from the 3421A front panel terminals. The TemperatureX commands must have a channel number present in the 41C/CV's X-Register prior to executing the command.

As before, in all functions where a channel number is required, that channel number is returned in the 41C/CV's LASTX register. The reading is returned to the X-register.

Function	Measurement Units	XROM Number	Description
RTD	°C	21,18	Performs a temperature conversion (European curve) on a 100Ω @ 0°C RTD
TSC	volts	21,19	These routines take a temperature (°C) from the 41C/CV's X-Register and converts it to the respective thermocouple's voltage output. TSC is for T-type thermocouples, JSC for J-Type, etc.
JSC	volts	21,21	
ESC	volts	21,23	
RSC	volts	21,25	
KSC	volts	21,27	
SSC	volts	21,29	
TTC	°C	21,20	These routines take a voltage from the 41C/CV's X-Register and converts it to a °C value corresponding to the type of thermocouple specified.
JTC	°C	21,22	
ETC	°C	21,24	
RTC	°C	21,26	
KTC	°C	21,28	
STC	°C	21,30	
THM5	°C	21,31	These two routines take a thermistor resistance measurement and converts it to a °C value. Use THM5 with a 5000Ω @ 25°C thermistor and THM2 with a 2252Ω @ 25°C thermistor.
THM2	°C	21,32	
C-F	°F	21,16	Converts a °C value in the 41C/CV's X-Register to the corresponding °F value.

Function	Measurement Units	XROM Number	Description
TEMTX	°C	31,01	These routines can be used to make a software compensated thermocouple temperature measurement. The channel 3421A channel where the measurement is to be made must be located in the 41C/CV's X-Register before executing these subroutines.
TEMJX	°C	31,02	
TEMEX	°C	31,03	
TEMRX	°C	31,04	
TEMKX	°C	31,05	
TEMSX	°C	31,06	
TWRTDX	°C	31,07	These two routines do a 2-wire or 4-wire (respectively) RTD temperature measurement. (see RTD subroutine.) Place channel to be measured in 41C/CV's X-Register before executing subroutine. Answer returned to X-Register.
FWRTDX	°C	31,08	
TWTH2X	°C	31,09	Do a complete 2-wire or 4-wire measurement and temperature conversion on a 2252Ω @ 25°C thermistor. Place channel to be measured in 41C/CV's X-Register before executing subroutine. Answer returned to X-Register. (see THM2 subroutine)
FWTH2X	°C	31,10	
TWTH5X	°C	31,11	Do a complete 2-wire or 4-wire measurement and temperature conversion on a 5000Ω @ 25°C thermistor. Place channel to be measured in 41C/CV's X-Register before executing subroutine. Answer returned to X-Register. (see THM5 subroutine.)
FWTH5X	°C	31,12	

Extended Function Commands

The following 17 commands are duplicated from the -hp- Extended Function ROM. Refer to that doumentation for more information.

Function	XROM Number	Description
ALENG	31,21	This function returns the number of characters in the ALPHA Register to the X-Register.
ANUM	31,22	The ANUM function searches the ALPHA Register for an alpha formatted number. If a number is found it is returned to the X-Register and flag 22 is set. If no number is found, the X-Register and flag 22 remain unchanged.
AROT	31,23	AROT rotates the contents of the ALPHA Register by the number of characters given in the X-Register. The ALPHA Register is rotated to the left if the number in the X-Register is positive, or to the right if the number is negative.
POSA	31,24	POSA scans the ALPHA Register for the characters in the X-Register and returns the position of the first character to the X-Register.
ATOX	31,25	This function deletes the left-most character in the ALPHA Register, converts it to a numeric character code, and places it in the X-Register. If the ALPHA Register is empty, the number 0 is placed in the X-Register.

Displayable Characters and Their Equivalent Codes

Char.	Code	Char.	Code	Char.	Code
–	0	3	51	N	78
↑	1	4	52	O	79
→	4	5	53	P	80
↓	5	6	54	Q	81
←	6	7	55	R	82
μ	12	8	56	S	83
▲	13	9	57	T	84
≠	29	:	58	U	85
space	32	;	59	V	86
!	33	<	60	W	87
"	34	=	61	X	88
#	35	>	62	Y	89
$	36	?	63	Z	90
%	37	@	64	[	91
&	38	A	65	\	92
'	39	B	66	]	93
(	40	C	67	↑	94
)	41	D	68	_	95
*	42	E	69	`	96
+	43	F	70	a	97
,	44	G	71	b	98
–	45	H	72	c	99
.	46	I	73	d	100
/	47	J	74	e	101
0	48	K	75	≥	126
1	49	L	76	⊢	127
2	50	M	77		

Function	XROM Number	Description
XTOA	31,26	Converts the number in the X-Register to its equivalent character and appends the character to the ALPHA Register.
SIZE?	31,27	This returns the number of data storage Registers in main memory to the X-Register.
PSIZE	31,28	Programmable SIZE function.

Function	XROM Number	Description
RCLFLAG	31,29	RCLFLAG recalls the status of flags 0 through 43 to the X-Register as ALPHA data. You can then store the contents of the X-Register for later use.
STOFLAG	31,30	If the flag status from the previously executed RCLFLAG command is placed in the X-Register, executing the STOFLAG command restores flags 0 through 43.
X<>F	31,31	Uses the number in the X-Register to set flags 0 through 7. At the same time, it transfers the previous status from those flags to the X-Register. In the X-Register, the flag status takes the form of a number from 0 to 255. The flags and their equivalent values are:

Flag	0	1	2	3	4	5	6	7
Numeric Equivalent	1	2	4	8	16	32	64	128

REGMOVE	31,32	Executing REGMOVE copies a block of nnn Registers, beginning at Register sss, to a block of the same length, beginning at Register ddd. Any data that was already in the destination block is lost. Load the X-Register with: sss.dddnnn before executing REGMOVE.
REGSWAP	31,33	Executing REGSWAP exchanges the contents of a block of nnn Registers beginning at Register sss with the contents of a block of the same length beginning at Register ddd. Load the X-Register with: sss.dddnnn before executing REGSWAP.

Function	XROM Number	Description
GETKEY	31,34	When a program executes GETKEY, execution stops until a key is pressed or an interval of approximately 10 seconds elapses. If a key is pressed, its keycode is placed in the X-Register. If no key is pressed, the number 0 is placed in the X-Register at the end of the time interval.
PCLPS	31,35	Programmable clear program.
PASN	31,36	Programmable ASN function.
CLKEYS	31,37	Clears all key assignments

Miscellaneous Commands

Most of the remaining 14 commands will be used when there are several different types of devices connected to the interface loop. The FIND accessory commands, for example can tell you what different types of devices (printers, mass storage, measurement instrument, etc) are connected to the interface and what their addresses are. This can be useful if manual addressing is desired. The CMD commands permit easy communication to a wide variety of devices. Finally, there are two commands specifically designated for the -hp- Model 3468A/B.

A Word about Accessory ID's

The Accessory ID (not to be confused with Device ID such as: HP3421) provides a fast, efficient means for simple controllers to identify specific devices and device classes. The ID is composed of a 2 digit decimal number; the first digit specifies the class of device such a printers, mass storage devices, measuring instruments, etc. These classes are shown in the following chart.

Class Number	Type of Device	Example of Device in Class
0	Controllers	-hp- 41C/CV
1	Mass Storage	82161A Digital Cassette Drive Devices
2	Printers	82162A Thermal Printer
3	Displays	
4	Interfaces	82166A HP-IL Converter
5	Instruments	3421A Data Acquisition/Control Unit 3468A/B Digital Multimeter

The second digit is used to specify certain features of devices within a particular class. Since the 44468A ROM is designed for use with instrumentation (device type 5x) there are 4 Find Accessory commands that locate specific type 5x devices. When a device is found, it HP-IL address is returned to the 41C/CV's X-Register. In the event that more than one device of the same type is connected to the interface, the address of the first one will be returned. If that device is "SELECTED" and the command repeated, the next device address will be returned.

Command	XROM Number	Description
FIND50	21,40	These FIND accessory ID commands search the interface loop for devices with specific capabilities:
FIND51	21,41	
FIND52	21,42	
FIND53	21,43	

Type	Capabilities
50 (FIND50)	Detector (measurement) capabilities such as a 3468A DVM.
51 (FIND51)	Scanner capabilities such as the 3421A.
52 (FIND52)	Source Capabilities such as a function generator.
53 (FIND53)	Instruments with an advanced or sophisticated function set. The 3421A belongs in this set because it has both measurement and scanner capabilities.

When the device is found, its HP-IL address is returned to the 41C/CV's X-Register.

Command	XROM Number	Description
FINDT	21,44	FINDT can be used to locate a particular class of device in the interface loop. For example, if you only desire to know if a printer (device type 2) is connected to the loop (your not concerned with its capabilities) put the number "2" (device type) in the X-Register and execute FINDT: 2 [XEQ] [ALPHA] FINDT [ALPHA] The address of the first (if any) printer connected in the interface loop will be returned to the X-Register.
FINDX	21,45	FINDX allows you to load an accessory number into the X-Register of the 41C/CV, execute FINDX and the address of that device will be returned.
FIND21	21,46	FIND21 returns the address of an -hp- 3421A connected in the interface loop.
CMD CMDX CMDXY	21,47 21,48 21,49	The CMD commands locate the first type 5 instrument connected to the interface, selects it and send it information of the following nature: CMD — Contents of 41C/CV ALPHA Register. CMDX — ALPHA Register followed by the absolute value of the integer portion of the X-Register. CMDXY — ALPHA Register, X-Register (as with CMDX) a "comma", the absolute value of the integer portion of the Y-Register. After the command is sent, the 41C/CV will check the instruments Status Register for a syntax error.
RDRGX	21,54	This command is to be used only with the 3421A and its reading storage feature. It allow you to have readings stored in the 3421A and transfer them to specified registers in the 41C/CV.

Command	XROM Number	Description
		Load the X-Register with bbb.eee (b = beginning, e = ending Register numbers) prior to executing RDRGX. If you have 30 readings stored in the 3421A then 30 registers should be allocated. If more registers are allocated than there are readings stored in the 3421A, error messages of all 8's will be sent after all available readings have been sent.
CLAL	21,55	This command is used to clear measage alarms that use the 41C/CV's ALPHA Register. Load the ALPHA register with the alarm mnemonic to be cleared. Then execute CLAL.
DSP68	21,50	The contents of the 41C/CV's ALPHA register are sent to the 3468A display.
CLD68	21,51	The 3468A display is cleared and returned to its normal display (measurement and function).

XROM Numbers

XROM numbers indicate that a function belongs to a plug-in accessory. When a 41C/CV program is written that utilizes one or more functions from an accessory module (such as the 44468A) and later the accessory is removed, a listing of that program would indicate the XROM numbers instead of the function name.

XROM numbers are in two parts. The first number identifies the accessory (XROM numbers 21 and 31 correspond to the 44468A ROM.) The second number identifies the particular function for that accessory.

SERVICE INFORMATION NOTICE

Hewlett-Packard currently offers the I/O options listed in Table 1 for the 3468A Digital Multimeter and the 3421A Data Acquisition/Control Unit.

Table 1. I/O Options

Option Number	-hp- Model Number
541	41CV Handheld Computer 82160A HP-IL Interface Module 82182A Time Module
561	82161A Digital Cassette Drive
562	82162A Thermal Printer/Plotter

In the United States, the Hewlett-Packard repair center for these I/O options is located in Corvallis, Oregon. The repair center for the 3468A is located in Mountain View, California. The repair center for the 3421A is located in Loveland, Colorado until August, 1983 after which time the 3421A repair center will also be in Mountain View, California.

Outside the United States, repair information is available from the nearest Designated Hewlett-Packard Sales and Service Office.

Please consult the appropriate Owner's Handbook, Operator's Manual, or Service Manual for complete service information.

44468-90000

Printed: U.S.A.